

Plan for assessment of environmental impacts of legacy uranium sites within the Grants Mineral Belt

Cibola, McKinley, and Sandoval counties, New Mexico

January 21, 2009



New Mexico Environment Department
Ground Water Quality Bureau
Superfund Oversight Section

Table of Contents

List of figures	3
1.0 Overview	4
2.0 Statement of problem	4
3.0 CERCLA investigation program objectives	5
4.0 Climate	5
5.0 Operational history and ownership	5
6.0 Current land use and demographics	6
7.0 Geologic setting	7
8.0 Current legacy uranium site regulatory status	7
9.0 Site investigation	8
9.1 Source/waste characteristics	8
9.2 Ground water pathway	11
9.2.1 Hydrogeology	11
9.2.2 Ground water use	12
9.3 Soil pathway	12
9.3.1 Soil exposure pathway description	12
9.3.2 Soil investigation results	12
9.4 Surface water pathway	13
9.4.1 Surface water exposure pathway description	13
9.4.2 Surface water hydrology	13
9.4.3 Surface water use	13
9.4.4 Surface water investigation	13
10.0 Air pathway	15
10.1.1 Air pathway description	15
11.0 Summary and conclusions	15
12.0 Tables	17
13.0 Figures	31

List of tables

Table 1: Legacy uranium mines within the Ambrosia Lake sub-district	18
Table 2: Legacy uranium mines within the Laguna and Marquez sub-district	21
Table 3: Legacy uranium mills within the Ambrosia Lake, Laguna, and Marquez sub-districts	22
Table 4: Regulated water systems within the vicinity of Ambrosia Lake, Laguna, and Marquez sub-districts	23
Table 5: Site assessment activities proposed for GMB	24

List of figures

Figure 1: Grants Mineral Belt.....	32
Figure 2: Ambrosia Lake legacy uranium sites shown by operator, showing surface ownership.....	33
Figure 3: Ambrosia Lake sub-district legacy uranium sites by production category, showing surface ownership.....	34
Figure 4: Ambrosia Lake sub-district legacy uranium sites by production method, showing OSE wells and municipal water systems	35
Figure 5: Laguna and Marquez sub-district legacy uranium sites, by operator showing surface ownership.....	36
Figure 6: Laguna and Marquez sub-district legacy uranium sites by production category, showing surface ownership.....	37
Figure 7: Laguna and Marquez sub-district legacy uranium sites by production method, showing OSE wells and municipal water systems	38
Figure 8: Ambrosia Lake proposed assessment activities	39
Figure 9: Laguna and Marquez sub-district proposed assessment activities	40
Figure 10: Conceptual model of contaminant migration within the GMB.....	41

1.0 Overview

The Grants Mineral Belt (“GMB”) was the primary locus of uranium extraction and production activities in New Mexico from the 1950s until late into the 20th century (see Figure 1). The GMB extends along the southern margin of the San Juan basin in Cibola, McKinley, Sandoval, and Bernalillo counties, New Mexico. Within the GMB, the Grants and Shiprock districts are designated mining districts. Three sub-districts located within the first three counties detailed above that have been designated within the Grants District—Ambrosia Lake, Laguna, and Marquez—contain the former uranium mines with recorded uranium ore production located outside of the boundaries of the Navajo Nation. Within the Ambrosia Lake sub-district, the New Mexico Energy, Minerals, and Natural Resources Department Mining and Minerals Division (“MMD”) has documented 76 formerly-producing mines and 4 former uranium mill sites outside of the boundaries of the Navajo Nation. Eighteen mine sites with historical production are recorded within the Laguna sub-district and one mine site is recorded within the Marquez sub-district. One former mill site also is located within Laguna subdistrict.

Thirty-eight uranium mine sites within other sub-districts of the Grants district and forty-seven uranium mine sites within 2 sub-districts of the Shiprock district with recorded ore production also have been documented within the boundaries of the Navajo Nation.

Uranium production in New Mexico is also recorded from other mines outside of the GMB, several of which are not within designated mining districts.

2.0 Statement of problem

Legacy uranium mine and mill sites either have had documented contaminant releases, or may have the potential to release contaminants. Additional investigation is required to determine the existence or extent of actual or potential impacts to receptors, as little assessment of this potential has occurred to date. These investigations are necessary to determine if releases to air, soil, streambed sediments, and ground water may occur or have already occurred and pose a threat to human health and the environment.

Few of the legacy uranium mine sites have undergone surface reclamation, and may have uncontrolled waste rock and ore piles on-site, as well as physical hazards such as open adits and shafts. Activities such as heap leaching within unlined pits, and mine water recovery (“MWR”) also occurred on some mine sites. Additionally, during operation, most of the underground mines in the Ambrosia Lake sub-district accessed ore bodies within the Westwater Canyon aquifer below the water table, necessitating large-scale dewatering operations that reportedly caused perennial surface water flows in San Mateo Creek and Arroyo del Puerto. At legacy uranium mill sites, tailings were accumulated in large unlined surface piles; these tailings comprise wet sand-sized concentrated

waste materials that are residual to the objective of uranium ore concentration. Additionally, mill operations generated large quantities of liquid process wastes containing concentrations of contaminants such as uranium, selenium, molybdenum, and nitrates. These liquid wastes were discharged to unlined surface impoundments, from which they either seeped into the alluvial soil/ground water systems, or overflowed into surface water courses, from which contaminants became entrained by sediments and directly introduced to ground water systems.

The actual or potential environmental impact of these waste streams to the alluvial ground water system has been documented in the few instances where abatement investigation at legacy uranium sites has occurred, but otherwise has been little assessed. The alluvial ground water system provides recharge to underlying bedrock aquifers via structural and stratigraphic interconnections; therefore ground water quality in these aquifers also should be assessed.

3.0 CERCLA investigation program objectives

The broad objectives of a program to assess legacy uranium sites are summarized as follows:

1. Investigate and document observed and suspected releases under CERCLA authority at legacy uranium sites to identify the potential for human and environmental exposures to released contaminants;
2. Establish collaboration among governmental agencies and governmental agency surface land owners to determine the appropriate regulatory framework to assess and remediate, if necessary contaminant releases from legacy uranium sites;
3. Identify and engage viable and compliant legacy uranium site owners and operators within appropriate regulatory frameworks for legacy uranium site assessment and abatement activities.

A broad outline of activities under the CERCLA process to assess legacy uranium sites would first establish priorities according to operational processes (i.e., uranium ore milling, conventional dry-adit mining, underground sub-water table mining, MWR, heap leaching), resultant waste streams (i.e., mill tailings, waste rock piles, ore stock piles, liquid waste impoundments and discharges). Details of proposed activities to address legacy uranium activities are shown in Table 5.

4.0 Climate

The regional climate is arid, with the majority of annual precipitation occurring as intense summer thunderstorms and as winter snowfall. High winds are prevalent, primarily during spring months.

5.0 Operational history and ownership

Table 1 gives details of land and surface ownership for legacy uranium mines within the Ambrosia Lake sub-district. Figure 2 illustrates the most prevalent

former operators of these mines within this sub-district. United Nuclear Corporation operated 12 mines within this sub-district, either alone or in partnership with other companies, principally Homestake Mining Company. Rio Algom LLC operated 8 mines, while Homestake Mining Company is recorded as the last operator of 6 mines. U.S. Bureau of Land Management ("BLM") is recorded as the total or partial surface owner of 20 of these sites, while the U.S. Forest Service owns the surface of 5 sites. The New Mexico State Land Office has partial or complete ownership of five mine sites. Table 2 and Figure 5 show the same information for the Laguna and Marquez sub-districts. ARCO (formerly Anaconda) is recorded as last operator for 15 of 17 mines within the Laguna district, all of which are located on land of Laguna Pueblo. The single mine recorded within the Marquez sub-district was operated by Kerr-McKee, on land owned by BLM.

Four legacy uranium mill sites are located within the Ambrosia Lake sub-district. The Anaconda Bluewater (a.k.a. Bluewater Disposal Site; CERCLIS ID NMD007106891), and Ambrosia Lake/Phillips mill (a.k.a. Ambrosia Lake Disposal Site; CERCLIS ID NMN000606875), are under the U.S. Department of Energy ("DOE") jurisdiction for long-term monitoring; the Homestake Mining Company uranium mill Superfund Site (CERCLIS ID NMD007860935) and Ambrosia Lake/Rio Algom are under the jurisdiction of the U.S. Nuclear Regulatory Agency ("NRC") for remediation. The Bokum mill was built within the Marquez sub-district, but never became operational. Table 3 shows details of ownership and operational processes; Figure 1 shows the locations of these mills.

6.0 Current land use and demographics

Current primary land uses within the vicinity of legacy uranium sites include residential, stock grazing, recreational, and Native American ceremonial. Additionally limited light commercial and agricultural uses are documented as well.

Within the Ambrosia Lake sub-district, the named communities include San Mateo and the Navajo community of Haystack. Other loci of population within the Ambrosia Lake sub-district include the vicinity of the junctions of highways 509 and 605, and subdivisions south of the Homestake Mining Company uranium millsite. Outside of the Ambrosia Lake sub-district, the communities of Grants (2000 population 8806), Milan (2000 population 1891), and Bluewater have municipal water systems that are sourced, in part, from aquifers underlying the Ambrosia Lake sub-district (see Figure 4).

Population centers within the Laguna sub-district (see Figure 7) include Pagate (2000 census district population 474) Cebolletita, Moquino, Seboyeta, Bibo, and Laguna (2000 census district population 423).

Comment [d1m1]: Can EPA assist to establish population in the communities mentioned here?

7.0 Geologic setting

Most uranium production in New Mexico has come from the Upper Jurassic Westwater Canyon member of the Morrison Formation in McKinley and Cibola counties. This unit consists of interbedded fluvial arkosic sandstone, claystone, and mudstone with an average thickness of 250 feet, thinning to 100 feet southward and eastward, and is a major aquifer within the GMB. Three types of uranium deposits that are found in the Westwater Canyon member are primary (trend or tabular; average ore grade greater than 0.20% U_3O_8), redistributed (stack; average grade 0.16% U_3O_8), and remnant-primary (average grade 0.20% U_3O_8). The overlying Brushy Basin member of the Westwater Canyon member includes the Poison Canyon Sandstone, from which uranium also has been mined.

Additionally uranium deposits at Haystack Butte in 1950 were discovered within the Upper Jurassic Todilto Limestone, which occurs within the San Raphael Group underlying the Morrison Formation; these accounted for approximately 2% of production from the Grants district between 1950 and 1981. More than 100 uranium mines and occurrences in the Todilto Limestone are documented in New Mexico, with production reported from 42 of these mines.

Thin zones of minor uranium mineralization have been produced from shale and lignite within the Lower Cretaceous Dakota Sandstone, which overlies the Morrison Formation. Uraniferous collapse-breccia pipe deposits, which are vertical or steeply-dipping cylindrical features bounded by ring fractures and faults filled with heterogeneous brecciated "country" rock, also are found in the Grants area.

The San Andres limestone, which is a prolific aquifer and source of water to many of the larger communities just south of the Ambrosia Lake sub-district, is reported by some references to be karstic. Additionally, the reported extensive interconnection of the underground mine workings within the northern part of the Ambrosia Lake sub-district has created karst-like subsurface conditions.

8.0 Current legacy uranium site regulatory status

Government agencies which are indicated to own the surface of mine sites within the Ambrosia Lake (figures 2 and 3), Laguna, and Marquez (figures 5 and 6) sub-districts include the BLM, U.S. Forest Service, and the New Mexico State Land Office.

NMED has submitted a Preliminary Assessment for legacy uranium sites located within the entire San Mateo Creek basin (CERCLIS ID NMN000606847) within the Ambrosia Lake sub-district, which includes both individual and groups of legacy uranium mine and mill sites that have been investigated previously under CERCLA authority. Of the four mill sites within the Ambrosia Lake sub-district, two millsites were reclaimed and subsequently transferred to DOE for long-term stewardship (e.g., the Bluewater and Ambrosia Lake [Phillips mill] disposal sites);

the other two mill sites in this vicinity (e.g., the Homestake Mining Company and the Ambrosia Lake/Rio Algom uranium mills) are still undergoing remediation under the primary jurisdiction of the NRC. Remediation of the L-Bar mill site within the Laguna sub-district was completed in 2001, and the site is currently under DOE jurisdiction.

The NMED Mining Environmental Compliance Section (MECS) oversees abatement of 9 uranium mine sites owned by Rio Algom LLC and one mine site owned by United Nuclear Corporation ("UNC") located within the Ambrosia Lake sub-district (see Table 1 and Figure 8; note that one mine site does not appear on either the table or the figure). Within the Laguna sub-district, MECS oversees abatement activities at two mine sites (see Table 2 and Figure 9).

MMD is assessing mine sites for new or additional reclamation activities. One program under this regulatory framework will develop site assessment and engineering design for approximately 20 abandoned mine sites, which are located primarily on BLM land in the Poison Canyon area of the Ambrosia Lake sub-district. These reclamation activities will only address surface disturbances, and do not include assessment of ground water impacts.

9.0 Site investigation

9.1 Source/waste characteristics

Solid wastes on legacy uranium mine sites may include piles of barren overburden and low-grade ore (i.e., below economic value), ore stockpiled for later milling, and treatment pond sludge. Underground mines generally produce less waste rock than surface mines, but contaminant concentrations can be higher. The majority of these materials were placed directly on the ground surface. Spoils areas in which waste materials were stored usually were not bermed to control runoff. Investigators from the New Mexico Environmental Improvement Division ("EID," predecessor to NMED) concluded that 10 to 20 percent of all abandoned mines in the GMB had waste piles that are directly eroding into local drainage channels. Waste material from the Navajo-Brown Vandever uranium mine (CERCLIS ID NMD986669117) was used to pave the road to this site, and approximately 75 people were identified to live with one-quarter mile of the site in 1990.

EID collected runoff samples from several sites to assess contaminant input from mine waste piles within the Ambrosia Lake mining sub-district; observations from this program indicated that runoff contaminant concentrations exceeded natural concentrations by up to several hundred times. Samples collected within the Ambrosia Lake mining district indicated that uranium and molybdenum maximum concentrations in waste pile runoff exceed natural runoff concentrations by over 2 orders of magnitude. Maximum arsenic, selenium, and vanadium concentrations exceed maximum natural runoff concentrations by 6 to 8 times. Runoff sampling in the vicinity of a large waste pile associated with the Old San Mateo mine

(location #30 in Table 1 and figures 1-5) showed elevated levels of gross alpha and gross beta particle activities, radium²²⁶, natural uranium, arsenic, lead, molybdenum, selenium, and vanadium, in comparison to natural sediments, to persist at least 550 meters downstream from the waste pile. A 1985 survey of 14 uranium mines located within the GMB, which includes individual minesites located within the Ambrosia Lake sub-district on federally-owned surface and mineral lands showed gamma radiation levels between 6 and 888 microrentgens per hour, with the highest reading taken from mine waste and openings.

Liquid wastes derived from legacy uranium mine sites include water produced from mine dewatering and aquifer depressuring operations, which was discharged to alluvium via direct discharge, and settling pond infiltration and overflow. Other sources of liquid wastes from legacy uranium mine sites include process waters from unlined on-site ore leach pads and old-stope leach operations which may impact ground water via direct discharges and infiltration. Such liquid waste discharges often reached major area drainages. Mine water production within the Ambrosia Lake mining sub-district was continuous after 1956, with peak production in the early 1960s. During the period 1979-1981, mine water discharges of 1,500 gallons per minute ("gpm") to San Mateo Creek sustained approximately 3 miles of perennial flow; 2,300 gpm discharge to Arroyo del Puerto sustained perennial flow of approximately 5 miles. In 1977, approximately 2,900 gpm were being discharged to San Mateo Creek from mine dewatering; by spring of 1978, most of this water was diverted for irrigation and to an adjacent drainage basin.

For compliance with federal National Pollutant Discharge Elimination System (NPDES) permits, produced waters were treated with the additions of a flocculent and barium chloride to reduce suspended solid concentrations and to co-precipitate radium. Effluent discharged to San Mateo Creek contained 300 to 600 mg/l TDS. Out of 9 trace elements for which treated minewaters were analyzed, molybdenum, selenium, and uranium concentrations were consistently higher than in natural runoff. Median total uranium concentration in mine effluents from the Ambrosia Lake mining sub-district was 1.6 mg/l, which was over 16 times greater than the corresponding median concentration in natural runoff. Median total molybdenum concentration in minewater from the Ambrosia Lake mining sub-district was 0.80 mg/l, which compares to the few samples of natural runoff in which total molybdenum concentration exceeded 0.01 mg/l. Total median selenium concentrations in treated minewater generally were less than 0.04 to 0.09 mg/l; however some treated effluents within the district approached 1.0 mg/l. Median total selenium concentration in natural runoff within the Ambrosia Lake mining sub-district is 0.03 mg/l. Arsenic, vanadium, and barium, the latter of which is added in the treatment process, were occasionally detected in significant concentrations in minewaters; cadmium, lead, and zinc were usually below detectable concentrations. Median total barium concentration was 0.212 mg/l. Elevated concentrations of arsenic and vanadium

in treated effluent (0.05 and 0.17 mg/l respectively) were only observed in association with the Homestake ion exchange facility, which was located within the Ambrosia Lake area.

Generally, treated minewaters contained trace elements and radionuclides in dissolved form; typically, these dissolved contaminant concentrations comprised more than 50% of the total. More than 85% of the total concentration of gross alpha activity, molybdenum, selenium and natural uranium occurred in the dissolved fraction, while radium²²⁶ concentrations averaged about 30% of the total. With the exception of natural uranium, radionuclide concentrations in minewaters in the dissolved phase were higher in comparison to concentrations in natural runoff. Dissolved gross alpha levels were several hundred to over 1,000 picocuries per liter ("pCi/L") in dewatering effluents. Mechanisms that were inferred to reduce contaminant concentrations most effectively in alluvial ground water impacted by mine water effluents include dilution, surface adsorption, cation exchange, precipitation, hydrodynamic dispersion, and molecular diffusion. Only radium²²⁶ and lead²¹⁰, among trace elements and radionuclides identified to have had elevated concentrations in effluent, underwent significant partitioning changes between dissolved and suspended phases with distance traveled; these constituents were usually became bound to precipitates and sediments and were lost from solution shortly after release. Once precipitated or bound to stream sediments, mine water contaminants could be moved downstream during natural or artificially-induced streamflow events. Within relatively sediment-free stream channels, these contaminants would stay in solution; dissolved radium²²⁶ concentrations along the Arroyo del Puerto ranged between 3 and 6 pCi/L. Dissolved radium²²⁶ concentrations also were attenuated by the alkaline and oxidizing conditions that are found in the GMB; however, concentrations of uranium, molybdenum, and major dissolved solids generally were not rapidly attenuated in the receiving stream channels.

Sludges in treatment ponds that are created from settling, flocculation, and precipitation had elevated concentrations of radium²²⁶ and other radionuclides, with concentrations of the former exceeding 200 pCi/gram. Ion-exchange treatment, which became prevalent at mine operations in the later years of operation, reduced elevated concentrations of dissolved uranium. Although this treatment also reduced concentrations of radium²²⁶, lead²¹⁰, polonium²¹⁰, natural uranium, and gross alpha activity in discharges, other constituent concentrations were not affected.

Solid wastes from legacy uranium mill sites include large volumes of sand-sized tailings, which contain concentrations of unwanted or unrecoverable contaminants. These waste materials generally were deposited on the unlined ground surface in a semi-saturated form, leaching contaminants into the subsurface during gravitational dewatering. Once dried, contaminants could be leached into the subsurface via periodic rainfall or flooding events, and distributed to surrounding areas via episodic high winds. Uranium mill tailings

also present a hazard for radioactive emissions, although, with the exception of the Homestake Mining Company mill site, the other legacy uranium mill sites within the GMB are located in areas that both are remote and have restricted access. Additionally, tailings are covered with radon and erosion barriers during reclamation under NRC's UMTRCA authority.

Liquid wastes from legacy uranium mill sites include large amounts of process waters that were oftentimes highly contaminated with ore constituents and process chemicals. These liquid wastes were discharged to unlined impoundments; at the Anaconda Bluewater uranium mill site, a deep injection well operated for several years to dispose of these wastes. Contamination of alluvial and bedrock aquifers and windblown contaminant dispersion have been documented at all legacy uranium mill sites.

Figure 10 is a conceptual model of contaminant migration to ground water, surface water, soil, and air.

9.2 Ground water pathway

The ground water pathway assesses the threat to human health and the environment by determining whether hazardous substances are likely to have been released to ground water; and whether any receptors are likely to be exposed to hazardous substances as a result of a release.

9.2.1 Hydrogeology

Both the San Andres and Westwater Canyon formations are important and prolific regional aquifers within the GMB. The San Andres formation is reported to be karstic in some references. Extensive interconnections among underground mine workings in the Ambrosia Lake sub-district also has created karst-like conditions.

Operations of the legacy uranium sites released both mine dewatering effluents and process waters to the environment. Discharges that occurred prior to the establishment of State and federal ground water regulations had little or no treatment prior to discharge to the land surface or to surface water channels. Bedrock aquifers are recharged where natural streamflows or minewater discharge intersect bedrock subcrops and outcrops. Additional bedrock aquifer recharge occurs where saturated valley fill overlies permeable bedrock with a downward hydraulic gradient. The Anaconda Bluewater mill operated a deep injection well to dispose of liquid wastes, which was documented to have contaminated aquifers overlying the target disposal formation. Current-day impacts to ground water from mine sites within the GMB mostly have not been assessed, but are indicated by the results from assessment and abatement work on a few mine sites within the Ambrosia Lake sub-district that have been ordered by the State under its ground water contamination abatement regulations.

Within the Ambrosia Lake sub-district, mine dewatering decreased aquifer water levels significantly, especially in the Morrison Formation. The Westwater Canyon member of the Morrison Formation is the principal ore-bearing strata, and also a principal bedrock aquifer in the area, with yields up to several hundred gallons per minute ('gpm'). Mine dewatering drained virtually all of this formation within this area, and also altered its flow system. Prior to dewatering, ground water generally flowed to the northeast and east in the direction of the dip of the strata. Current data indicate that ground water is now flowing toward the mine site where extensive pumping had occurred during operation. Other reliable aquifers within the San Mateo Creek basin include the Dakota Sandstone, the Glorieta Sandstone, and the San Andres Limestone.

9.2.2 Ground water use

Ground water uses include domestic, limited agricultural, light industrial, and livestock watering. Fourteen regulated public water supplies are located within or just outside of the Ambrosia Lake, Laguna, and Marquez sub-districts, which collectively serve an estimated population of 15710 (see Table 4). Wells recorded by the New Mexico Office of the State Engineer

9.3 Soil pathway

The soil exposure pathway assesses the threat to human health and the environment by direct contact with hazardous substances and areas of suspected contamination. This pathway addresses any material containing hazardous substances that is on or within two feet of the surface and not capped by an impermeable cover.

9.3.1 Soil exposure pathway description

Legacy uranium site impacts to soils within GMB may originate from discharges of mine dewatering and mill process effluents to the land surface, and from the placement of solid-form waste materials (e.g., mine wastes, ore stockpiles, mill tailings) into unlined surface piles. Additional contaminant distributions to soils may originate from wind-blown dispersion of the on-site solid-form waste materials.

9.3.2 Soil investigation results

Pond and stream sediment analytical and soils analytical data collected from the Poison Canyon Mining District, in comparison to background samples collected within the same area, indicate elevated concentrations of uranium₂₃₈, uranium₂₃₄, thorium₂₃₀, radium₂₂₆, lead₂₁₀, vanadium, lead, and copper in one or more of these samples. Selenium is locally enriched in soils and plants in the Poison Canyon area.

The investigation of soil impacts from dewatering activities associated with the Section 35 and 36 mines indicate that radium₂₂₆ and uranium concentrations in soil, while decreasing with increasing depth, exceed assumed background concentrations. Exclusive of arsenic, total metals concentrations are below

NMED Soil Screening Levels, and leachable metals (excluding selenium) and major ions concentrations, and TDS are below New Mexico Water Quality Control Commission (WQCC) standards.

9.4 Surface water pathway

The surface water pathway assesses the threat to human health and the environment by determining whether hazardous substances are likely to have been released to surface water; and whether any receptors (e.g., intakes supplying drinking water, fisheries, sensitive environments) are likely to be exposed to a hazardous substance as a result of a release.

9.4.1 Surface water exposure pathway description

Surface water within the GMB is mostly ephemeral, the result of heavy rainfall events. However some springs produce flows that can extend short distances. Additionally small stock dams in drainages and streambed depressions accumulate and store surface water flows.

The discharge of legacy uranium site dewatering and process effluents, and contaminant leaching from exposed mine and mill site wastes and ore stockpiles caused contaminant adsorption to streambed sediments, from which these can become remobilized during subsequent surface water flows.

9.4.2 Surface water hydrology

Peak runoff from heavy late-summer thunderstorms and lesser flows from snow melt in late winter and early spring carry high sediment loads. San Mateo Creek has flowed continuously since construction of San Mateo Reservoir near the community of San Mateo; however this flow usually is ephemeral within 1 mile below the village of San Mateo. Average stream bed loss along San Mateo Creek is approximately 0.72 cubic meters per minute per kilometer. Infiltration rate in the Ambrosia Lake sub-district was calculated to be 7.54 cubic meters per minute.

9.4.3 Surface water use

Surface water in the GMB, both from natural or mining-impacted sources, has been used for livestock watering. No domestic use of surface water has been documented. Named streambed pools on topographic maps suggest that some persistent streambed impoundments may be used for swimming.

9.4.4 Surface water investigation

Surface water monitoring was conducted by EID between 1977 and 1982 from stations established in San Mateo Creek and Arroyo del Puerto to characterize the quality of natural surface waters and the impacts of uranium mining to these waters—specifically to characterize hydraulic and contaminant migration relationships between surface water and shallow ground water. Monitoring locations included flow from both uranium mine dewatering effluents and natural perennial flow. Additionally, single-stage samplers were installed within

ephemeral watercourses above and below mine waste piles to characterize runoff, and grab samples were collected during runoff events above and below waste piles.

Natural runoff has average suspended sediment concentrations greater than 30,000 mg/l. EID investigators concluded that TDS concentrations in perennial stream flows throughout the GMB varied between less than 200 to greater than 1,500 mg/l, with the lowest TDS values found in the perennial flow of San Mateo Creek. TDS concentrations in flow within Arroyo del Puerto that was influenced by mine discharge were 1,500 to 2,000 mg/l; occasionally natural waters diluted these concentrations to less than 1,000 mg/l.

Flow within San Mateo Creek typically has suspended sediment concentrations less than 400 mg/l. In natural runoff, contaminants are generally associated with suspended sediment and precipitates. Natural runoff has median concentrations of total molybdenum and selenium of less than 0.01 and 0.03 mg/l respectively. Median total barium concentration in natural runoff is 7.7 mg/l. As much as 99% of the gross alpha and gross beta particle activities in natural runoff are associated with precipitates and suspended sediment. Dissolved gross alpha levels are generally less than 20 pCi/L, with dissolved uranium accounting for more than 80 percent. Total radium²²⁶ concentration in natural runoff often exceeds 15 pCi/L, but usually has less than 2 pCi/L of dissolved radium²²⁶. Natural runoff typically has concentrations of total lead²¹⁰ and polonium²¹⁰ between 40 and 90 pCi/L respectively.

Dissolved trace element and radionuclide concentrations in both perennial and ephemeral flows throughout the GMB are very low, due to the low solubility of these materials and the prevailing neutral to slightly alkaline nature of the flows. Suspended sediment concentration in the San Mateo perennial flow had a log mean concentration of 10 mg/l, while ephemeral flow in the same streamcourse had a log mean concentration of 8,100 mg/l. Total trace element and radionuclide concentrations in natural runoff generally were dependent upon sample sediment amounts. Molybdenum was virtually absent from runoff. In turbid waters, gross alpha particle activity among 5 samples ranged from 33 pCi/L to 2,100 pCi/L, with a median concentration of 1,200 pCi/L. Gross beta particle activity among 4 samples ranged from 546 pCi/L to 2,000 pCi/L, with a median concentration of 1,060 pCi/L. The majority of radium²²⁶ and lead²¹⁰ concentrations found in turbid water samples were bound to sediments. Maximum gross alpha particle activity exceeded maximum natural runoff activity by 200 times. Maximum levels of natural uranium and radium²²⁶, which are two major alpha particle emitters, exceed natural maximum runoff levels by over 100 times. Gross beta particle activity, especially from lead²¹⁰, also far exceed natural runoff levels.

10.0 Air pathway

The air pathway assesses the threat to human health and the environment by determining whether hazardous substances are likely to have been released to the air; and whether any receptors (e.g., human population and sensitive environments) are likely to be exposed to hazardous substances as a result of a release. The need to characterize this pathway will be dependent upon waste characteristics at, and population densities near, individual mine and mill sites.

10.1.1 Air pathway description

Accumulations of on-site solid wastes may emit radioactivity and radon gas. As previously indicated, these solid wastes become dispersed by wind, thus increasing the possibility of human exposures to airborne contamination beyond legacy uranium sites. As previously indicated, these exposure routes should be controlled at legacy uranium mill sites after reclamation under NRC.

11.0 Summary and conclusions

The State of New Mexico Environment Department has identified a total 95 formerly-producing legacy uranium mine sites that are located within three sub-districts of the GMB outside of Navajo Nation jurisdiction, which operated during the last half of the 20th century. Within the Ambrosia Lake sub-district, United Nuclear Corporation operated the largest number of these mines. NMED's Mining Environmental Compliance Section currently oversees assessment and abatement activities at eight mine sites within this sub-district that were operated by Rio Algom LLC, and one mine site that was operated by United Nuclear Corporation. Within the Laguna sub-district, MECS oversee abatement activities at two legacy uranium mine sites. Additionally six formerly-active uranium mill sites are located among these sub-districts. Of the four that are located within the Ambrosia Lake sub-district, two are currently under long-term monitoring by DOE, and two are still undergoing remediation under NRC oversight. The L-Bar mill site in the Laguna sub-district is also under DOE long-term stewardship, while the Bokum mill was never operational.

Waste materials from these sites are documented to have contaminated sediments and alluvial ground water where these have been investigated. Additionally remedial activities that have been conducted at the mill sites have documented contamination of ground water in underlying bedrock aquifers as well. These waste materials include mine overburden, ore stockpiles, and process and dewatering effluents from the mine sites, and tailings and process effluents from the mill sites. Impacts to alluvial sediments and ground water may have occurred as a result of the deposition of solid-form waste materials directly on the ground surface, the wind-blown dispersion of solid-form waste materials, and the discharge of process and dewatering effluents during operation. The impacts to alluvial ground water may disseminate to ground water of underlying bedrock aquifers through structural and stratigraphic juxtapositions, and through manmade interconnections such as underground mine working; additionally the

operation of a deep injection well for disposal of liquid process wastes is documented at the Anaconda Bluewater mill site.

NMED herein proposes to review available data from legacy uranium sites to ascertain proper regulatory authorities and viable potentially responsible parties for these legacy uranium sites. At the same time that this effort is undertaken, SOS will undertake assessment activities as outlined in Table 5 and Figures 8 and 9.

12.0 Tables

Table 1: Legacy uranium mines within the Ambrosia Lake sub-district

Minesites currently addressed under ground water abatement regulation by NMED MECS

Map ID	Mine Name	Aliases	Surface Owner	Last Operator
12	Section 30	Carter 1-36, Mining Unit 30	Rio Algom	Rio Algom LLC
15	Section 23		Rio Algom	Homestake Mining Co.
16	Section 24	Section 24 and 26, Mine No. 24	Rio Algom (Sec 24)	Rio Algom LLC
17	Cliffside	Section 36	State Land Office (Sec 36), Isabella O. Marquez Trust (Sec 1)	Rio Algom LLC
18	Section 25	Homestake Sapin No. 25	Homestake Mining Co., Elbert Roundy Ranch	Homestake Mining Co.
19	Section 35	Elizabeth	Rio Algom	Rio Algom LLC
21	Section 17	Jerry Wayne No.. 1-36, Carter, Shale No. 1-36	Rio Algom (Sec 17,18), Bureau of Land Management (Sec 20)	Rio Algom LLC
22	Section 33	Mining Unit 33, Branson	Rio Algom	Rio Algom LLC
23	Ann Lee	Phillips No. 1, Section 28, Spider Rock	United Nuclear Corp.	United Nuclear Corp.
26	Section 27	United Nuclear	Schmitt Ranch	United Nuclear Corp.
27	Section 15	Homestake Sapin Mine No. 15	Jerry & Luann Elkins	Homestake Mining Co.
28	Sandstone	Section 34	United Nuclear Corp	United Nuclear Corp.
29	John Bully	John Bully shaft	United Nuclear Corp	United Nuclear Corp.
30	San Mateo	Section 30, Rare Metals	U. S. Forest Service	United Nuclear Corp.
31	Section 32	UN-HP	State Land Office (Sec 32), private	Homestake Mining Co.
32	Johnny M	Ranchers	John E. Motica, Fernandez Co.	Hecla (Ranchers Exploration & Development)
35	Section 30 West		Rio Algom	Rio Algom LLC
36	Section 19	Section 20	Rio Algom (Sec 19), Bureau of Land Management (Sec 20)	Rio Algom LLC
38	Section 13	Westwater Corp.	Jerry & Luann Elkins	Homestake Mining Co.
39	Marquez	Marcus, Calumet	Marquez Trust	United Nuclear Corp.
40	Divide	Section 25	Elkins Real Estate, Berryhill Ranch, Ltd.	Four Corners Exploration Co.
41	Dysart No. 1	Rio de Oro, Section 11	Homestake Mining Co.	United Nuclear - Homestake Partners
43	Dog	Dog Incline, Dog-Flea, BG Group, Section 20	Bureau of Land Management	Four Corners Exploration Co.
44	Section 25 SEQ	Desiderio, Amiran, Operation Haystack, Rimrock No. 1	Elkins Real Estate, Berryhill Ranch, Ltd.	Amiran Co. Ltd. - Reserve Oil & Minerals
45	Poison Canyon	Moe No. 1	Elkins	Todilto Exploration & Development, Reserve Oil & Minerals

Map ID	Mine Name	Aliases	Surface Owner	Last Operator
46	Bucky	Section 14, Jeep No. 1-6, Buckey, Buckly	Southwest Resources Inc	Cobb Resources
48	Section 10	Kermac, Regomex, Ambromex, Buffalo	Southwest Resources Inc	Cobb Resources
49	Barbara J No. 3	Barbara Jean No. 3, Fife and Bailey	Bureau of Land Management	Todilto Exploration & Development
50	Roundy Manol Strip	Manol, F. Manol, Roundy Lease, Rimrock No. 3, Section 30		Bailey & Fife
52	Isabella	Section 7	Marquez Trust	Hecla (Ranchers Exploration & Development), United Nuclear Corp.
53	Section 12	Dysart Group, Tana and Alto	Southwest Resources Inc	Cobb Resources
54	Malpais	Malpais No. 13, Dog No. 10, East Malpais, Malpais raise	Bureau of Land Management	Four Corners Exploration Co.
55	Barbara J No. 2	Dalco, Bailey & Fife, X-C, 30-C, Rimrock No. 3	Bureau of Land Management	Mid-Continent Uranium
57	F-33	Section 33, Anaconda, Forest Group, Head & Keely	Elkins	Homestake Mining Co.
60	Doris	Section 21, Doris No. 1, Little Doris, Doris decline, Flea-Doris extension, Doris West Extension	Schmitt Ranch	Hecla (Ranchers Exploration & Development), M&M Mining
65	Section 25 shaft		Elkins Real Estate, Berryhill Ranch, Ltd.	Farris Mines
66	Mount Taylor	Gulf, Chevron	Rio Grande Resources, Inc.	Rio Grande Resources
68	Flea	Flea-Doris Extension	Bureau of Land Management (Sec 20), State Land Office (Sec 16), Schmitt Ranch (Sec 17& 21)	United Nuclear - Homestake Partners, M&M Mining
69	Section 25 Decline	Tag claims, Red Rock	Elkins Real Estate, Berryhill Ranch, Ltd.	Amiran Co. Ltd. - Reserve Oil & Minerals
70	Section 25 Open Pits	Desiderio, Amiran	Elkins Real Estate, Berryhill Ranch, Ltd.	Amiran Co. Ltd. - Reserve Oil & Minerals
71	Roundy Shaft	Rimrock No. 1, Section 30, H-H-50, Golden P. Roundy		Todilto Exploration & Development
72	T-20	T-9, Rimrock No. 2, Q-32	Bureau of Land Management	Bailey & Fife
74	Black Hawk, Bunney, Red Bluff Nos. 7, 8 & 10, UDC, Gay Eagle	Section 4, Bunney Group	Bureau of Land Management, private	Bailey & Fife
75	La Jara	Zia, La Jara No. 1-9	U. S. Forest Service	Chena Mining Co.
76	Zia		U. S. Forest Service	Chena Mining Co.
77	Red Bluff No. 1, 2, 3, 4, 5, 9	Elkins and Jones		Moises Mirabel
79	Section 9	Mark Elkins, Anaconda		Farris Mines
82	Barbara J No. 1	Barbara Jean No. 1, Whitecap, Dalco	Bureau of Land Management	Mid-Continent Uranium
83	Beacon Hill Gossett	Section 18, Moe No. 3	Bureau of Land Management	Todilto Exploration & Development, Reserve Oil & Minerals
84	Beacon Hill	Mesa Top No. 7, Beacon Hill No. 18-23	Bureau of Land Management	Farris Mines
85	Blue Peak	Garcia No. 1-5, Red Top No. 1-10, Section 24	Bureau of Land Management	Garcia Mines
86	Davenport	Moe No. 2, Davenport Incline; Mesa Top No. 7	Bureau of Land Management	Bailey & Fife
87	Dysart No. 2	Section 11, SE Shaft	Southwest Resources	Cobb Resources
89	Faith	Section 29, Westvaco	Schmitt Ranch	United Nuclear Corp.

Map ID	Mine Name	Aliases	Surface Owner	Last Operator
90	Flat Top	Fife and Bailey, Vilatie Hyde	Bureau of Land Management	Bailey & Fife
91	Hogan	Lucky Dooley, Fence, Plain	Robert Sandoval	United Nuclear - Homestake Partners
93	Hope	Section 19	Elkins	Hecla (Ranchers Exploration & Development)
95	Mary No. 1	Section 11 NWQ, Dysart No. 3	Homestake Mining Co.	United Nuclear - Homestake Partners
96	Mesa Top	Mesa Top No. 18, Beacon Hill No. 18-20	Bureau of Land Management	Holly Minerals
97	Vallejo	Double Jerry, Section 34, Farris No. 1	U. S. Forest Service	Penta Mining Co.
98	Spencer	Section 8, Centennial, State No. 1-27 claims	Bureau of Land Management	Koppin Mining Co.
101	Chill Willis	Rialto, Section 13, Section 24	Marquez Ranch	Farris Mines
103	Haystack Section 31	Santa Fe Railroad, Henri Dole, Section 31	Isabella O. Marquez Trust	United Nuclear Corp.
104	United Western	J and M, Section 36, Lease 60-167, VCA mine	State Land Office	United Western Mining
117	Cedar	Cedar 1, Section 20, Yucca, A. Head, J.Kealey, Falcon, City View	Bureau of Land Management	Utco Uranium Co.
119	Christmas Day	Phil, Christmas Day No. 1-4		Colamer Corp.
121	Gay Eagle			Chena Mining Co.
122	Last Chance	Bottoms		Broaddus
123	Lone Pine	Lone Pine No. 3, Little Haystack No. 1-29, John No. 1-4, Double X 3-5	Bureau of Land Management	Permian Basin Uranium Co.
126	Taffy	Bonanza No. 1, Trustco Corp	U. S. Forest Service	Lummus & Muriel, Trustco Corp.
127	Tom	Tom No. 13, Tom Group, Vanadium	Bureau of Land Management	ARCO (Anaconda)
141	Bobcat		Bureau of Land Management	Brown & Wallace
143	Charlotte	Section 33, Farris	Sonny & Isabel Marquez	Westvaco, Farris Mines
157	Piedra Trieste	Section 30, Piedra Lisa	Bureau of Land Management	Todilto Exploration & Development
168	Moe No. 4	Section 32	State Land Office	L. Sutton & E.P. Moe
172	Red Bluff No. 1	Rimrock, Homer Scriven, Section 36	State Land Office	Homer Seriven

Table 2: Legacy uranium mines within the Laguna and Marquez sub-district

Minesites currently being addressed under ground water abatement regulation by NMED MECS

MapID	Mine Name	Aliases	Surface Owner	Last Operator
1	Jackpile	Jackpile-Paguete	Laguna Pueblo	ARCO (Anaconda)
2	Alpine	Alpine Test	Laguna Pueblo	ARCO (Anaconda)
3	H-1		Laguna Pueblo	ARCO (Anaconda)
4	NJ-45		Laguna Pueblo	ARCO (Anaconda)
5	Oak Creek Canyon		Laguna Pueblo	ARCO (Anaconda)
6	P-9-2	F-9-2	Laguna Pueblo	ARCO (Anaconda)
7	P-9-3		Laguna Pueblo	ARCO (Anaconda)
8	P-10	Townsite	Laguna Pueblo	ARCO (Anaconda)
9	P-11		Laguna Pueblo	ARCO (Anaconda)
10	P-13		Laguna Pueblo	ARCO (Anaconda)
11	PW 2, 3		Laguna Pueblo	ARCO (Anaconda)
33	J. J.	L-Bar, Sohio, J.J. No. 1	Cebolleta Land Grant	Kennecott Energy Co. (Sohio)
78	Saint Anthony	Seboyeta, Hanosh, M-6, Bibo, Cebolleta Grant, Willie P ore body	Cebolletta Land Grant	United Nuclear Corp.
80	Woodrow		Laguna Pueblo	ARCO (Anaconda)
120	Crackpot	Anaconda	Laguna Pueblo	ARCO (Anaconda)
124	Paisano	Balo Mining Claims, Paisano No. 23	Laguna Pueblo	Q3 Good News Mining
125	Sandy	South Laguna, Pit I and II	Laguna Pueblo	ARCO (Anaconda)
128	Windwhip	Wind Whip	Laguna Pueblo	ARCO (Anaconda)

Table 3: Legacy uranium mills within the Ambrosia Lake, Laguna, and Marquez sub-districts

Sub-District	Mill	Surface Status	Mill Process	Last Operator
Ambrosia Lake	Rio Algom	private	2 mills, ion-exchange plant	Rio Algom LLC
Ambrosia Lake	Homestake mill	private	alkaline-leach mill	Homestake Mining Co.
Ambrosia Lake	Bluewater mill	private	carbonate-leach (1953-1959) & acid-leach (1957-1982)	ARCO (Anaconda)
Ambrosia Lake	Phillips mill	federal	alkaline pressure leach (1958-1963); ion exchange plant for mine waters (mid-1970s -1982)	United Nuclear Corp.
Marquez	Bokum mill	private	mill constructed, never operated	Bokum Resources
Laguna	L-Bar	private	sulfuric acid leach	Kennecott Energy Company

Legacy uranium mill site under DOE long-term stewardship
Legacy uranium mill site under NRC jurisdiction

Table 4: Regulated water systems within the vicinity of Ambrosia Lake, Laguna, and Marquez sub-districts

NM water system reference number	Water system name	Number of wells	Population served
NM3500332	Correo Water Association	3	161
NM3525533	Milan Community water system	3	1911
NM3525633	Moquino water system	1	31
NM3525733	San Mateo MDWCA	1	192
NM3525933	Seboyeta water system	1	290
NM3526033	Bibo mutual domestic water association	2	263
NM3526133	Grants domestic water system	2	8892
NM3596017	Lee Ranch Coal Company	2	238
NM3597233	Mount Taylor millworks	1	65
NM3501232	Highland Meadows Estates MDWCA	3	61
NM3595333	Cubero Elementary School	1	220
NM3595733	Acomita Rest Area	1	2501
NM3595017	Tri-State Generating Station	3	125
NM3525033	Bluewater Water and Sanitation District	1	560
NM3594933	Bowlins B;iewater Dairy Queen Store	2	200

Table 5: Site assessment activities proposed for GMB

Potential contaminant release pathway	Proposed activity timeframe	Activity		Rationale	Comments	Required resources additional to NMED
NA	2008 ongoing	Compile historical site owner and operator, and chemical (e.g., ground water, surface water, and sediment chemical, and radioactivity) data into a geodatabase.		An increasing quantity of analytical data has been collected since the very early days of uranium extractive activities. In order to assess potential impacts to the environment, it is important to be able to analyze the chemical changes that may have occurred over time in various environmental media that potentially have been impacted from legacy uranium sites.	<ul style="list-style-type: none">NMED has compiled much of these historical data into an Excel spreadsheet.	
NA	ongoing	Assess available information from legacy uranium sites to determine the appropriate regulatory framework for investigation and remediation.	<ol style="list-style-type: none">1. Review available legacy uranium site surface owner and operator data.2. Confer with appropriate regulatory agencies and government agency surface owners.3. Initiate assessment and abatement activities at sites, as appropriate.	Where possible, the application of existing state and federal regulatory programs may address environmental assessment and restoration of legacy uranium sites both more appropriately and quickly than actions under CERCLA.	<ul style="list-style-type: none">Current applicable State regulatory programs include mining environmental compliance, hazardous waste, AML reclamation, and Superfund oversight.Applicable federal regulatory programs include UMTRCA, AML, and CERCLA.	
Ground water, soil, air	2008 ongoing	Enforce water quality abatement regulations through identification of viable uranium mine owners, issuance of orders for mine site environmental assessment and abatement activities, and administration of discharge permits.		MECS enforces state WQCC ground water protection regulations by identifying viable legacy uranium mine owners and operators, and issuing orders for assessment and abatement actions.	<ul style="list-style-type: none">NMED MECS currently is overseeing assessment and abatement activities for legacy uranium mines owned by Rio Algom LLC, a single mine owned by United Nuclear Corporation, and is involved in reclamation oversight of the Ambrosia Lake/Rio Algom mill, all of which are located in the Ambrosia Lake sub-district. Additionally MECS oversees restoration activities associated with two mine sites within the Laguna sub-district.	

Potential contaminant release pathway	Proposed activity timeframe	Activity		Rationale	Comments	Required resources additional to NMED
Ground water, soil, air	2008 ongoing	Assess and reclaim abandoned uranium mine sites where no viable owner can be identified.		New Mexico Energy, Minerals, and Natural Resources Department Mining and Minerals Division administers the following programs that include legacy uranium sites: <ul style="list-style-type: none">Identifying and assessing prior mine reclamation activities, and needs for additional mine site reclamations.Development of site assessment and engineering designs planning for approximately 20 abandoned uranium mine sites primarily located on BLM land in the Poison Canyon area.	<ul style="list-style-type: none">These programs address only surface reclamation, and do not evaluate potential ground water impacts.	
Ground water, soil, air	2009 ongoing	Conduct risk assessments of area residents to assess potential health impacts from proximity exposures to legacy uranium sites		Releases to ground water, soil and air have been documented from legacy uranium sites throughout the Ambrosia Lake sub-district. Area residents have requested an assessment of health risks associated with environmental impacts from known and projected legacy uranium activities and wastes in the San Mateo Creek basin.	<ul style="list-style-type: none">NMED requests that this effort be expanded to other potentially impacted areas within the Grants Mineral Belt that was announced in 2008.	<ul style="list-style-type: none">Risk assessment
Air	2009	Establish air monitoring stations within population loci within the GMB to quantify air quality impacts from the proximity of legacy uranium sites		Radon and wind-blown contaminant releases from legacy uranium sites may impact the health of area residents, as well as temporal users within the vicinity of legacy uranium sites.	<ul style="list-style-type: none">NMED has identified the following population loci within close proximity to legacy uranium sites:<ul style="list-style-type: none">× Ambrosia Lake sub-district<ul style="list-style-type: none">Haystack (Navajo)intersection of highways 605 and 509San Mateosubdivisions south of the HMC SitePoison Canyon× Laguna sub-district<ul style="list-style-type: none">Pagate	<ul style="list-style-type: none">Airshed analysisAir monitoringData interpretation

Potential contaminant release pathway	Proposed activity timeframe	Activity		Rationale	Comments	Required resources additional to NMED
Ground water	2008 (completed)	Sample accessible private water wells that are completed in the San Andres aquifer in a traverse across the Anaconda Company Bluewater uranium mill site to determine whether contaminant release to ground water has occurred from this site.	1. Conduct field reconnaissance of private wells available within proposed study area to determine usage modes and obtain owner access. 2. Compile data on wells available from OSE, local well drillers, and well-owners 3. Collect ground water samples for analyses of metals, wet chemistry, PCBs concentrations, and radionuclide activity.	NRC and DOE document releases to the San Andres/Glorieta and Alluvial aquifer during operational period of the Anaconda Company Bluewater mill. This site is located upgradient of the HMC site with respect to ground water flow within the former aquifer. No legacy uranium sites are known to be upgradient of this site. The San Andres aquifer is a prolific regional aquifer that supplies water to the municipal water systems of the communities of Grants, Milan, and Bluewater, as well as to individual residences. Exceedances of drinking water standards for some contaminants that may be associated with the Bluewater site have been documented in San Andres monitor wells upgradient of the HMC site.	<ul style="list-style-type: none">The Anaconda Bluewater uranium mill site is currently under the administration of the U.S. Department of Energy (DOE) for long-term monitoring under UMTRCA. Before the DOE assumed this long-term monitoring responsibility, ARCO (successor owner to the Anaconda Company) conducted ground water remediation of documented contaminant releases to San Andres/Glorieta aquifer.Documentation and owner knowledge of well completion details for many wells in this study area is of poor quality; therefore not all wells that were sampled may reflect hydrochemistry of the same zones in the aquifer.NMED was unable to verify flow direction and gradient in neither the San Andres aquifer nor in most wells sampled, and therefore relied upon available historical data as well as data provided by the Homestake Mining Company.	
	2009/TBD		4. Analyze data from sampling event. 5. Conduct follow-up sampling of wells as indicated by analysis for selected radionuclide isotopes to characterize possible isotopic signature of uranium mill contaminant release. 6. Identify and address data gaps.			

Potential contaminant release pathway	Proposed activity timeframe	Activity		Rationale	Comments	Required resources additional to NMED
Ground water and soil	TBD	Sample alluvial ground water and stream bed sediments within major drainage below the Anaconda Company Bluewater uranium mill site to determine whether contaminant release has impacted this aquifer.	<ol style="list-style-type: none">1. Conduct resistivity survey to determine areas of alluvial saturation within a transect across the mill site.2. Sample existing monitor wells on the mill site that are completed in the Alluvial aquifer.3. Install monitoring points to collect Alluvial ground water samples for analyses of metals, wet chemistry, PCB concentrations, and radionuclide activity.4. Collect stream bed sediment samples in transects within drainages in the vicinity of the mill site.5. Analyze data from sampling events6. Identify and address data gaps	<p>In general, contaminant releases from legacy uranium sites via erosion of exposed solid-form waste materials and liquid waste overflow and infiltration from unlined impoundments would first impact Alluvial sediments and ground water. From such releases, impacts could propagate to underlying bedrock aquifers via structural, stratigraphic, and/or constructed interconnections. Additionally, released contaminants may become adsorbed to sediments, and be transported episodically in response to ephemeral streamflows from heavy rainfall events that are characteristic of the regional climate.</p> <p>Contaminant releases to the Alluvial aquifer have been documented at the Anaconda Bluewater Site, as well at other legacy uranium sites that have been investigated within the GMB. These contaminants may impact the underlying bedrock aquifer, including the San Andres. Concentrations of many contaminants associated with legacy uranium sites generally exceed drinking water standards within Alluvial ground water downgradient of the Bluewater site. As for the San Andres aquifer, this site also is located upgradient of the Homestake Mining Company (uranium mill site) Superfund Site with respect to ground water flow in the Alluvial aquifer, with no known upgradient legacy uranium sites.</p>	<ul style="list-style-type: none">• Outside of Alluvial Points of Compliance and Exposure wells on the mill site, no existing wells completed in the Alluvial aquifer have been identified. Therefore, additional resources may be needed for this investigation.	<ul style="list-style-type: none">• Geophysical survey• Drilling• Well installation

Potential contaminant release pathway	Proposed activity timeframe	Activity		Rationale	Comments	Required resources additional to NMED
Ground water	2008 (ongoing)	Sample accessible private water wells within the San Mateo Creek basin in an area extending from north of the Homestake Mining Company Superfund Site and east of the border of the Navajo Nation to the north and west to determine concentrations of contaminants and geochemical indicators possibly related to SMC legacy uranium sites	1. Compile and review available water quality data, including data from operators conducting background investigations related to proposed new mining operations. 2. Conduct surveys of residents to locate and secure access to available private wells for future sampling, and to determine well water usages and well information. 3. Review available private well data, with matches to survey information where possible.	Residents within the Ambrosia Lake and Laguna sub-districts primarily rely on private wells for residential-domestic, stock-watering, and agricultural uses. Mine dewatering and mill effluents during legacy site operations, and subsequent contaminant-laden runoff are documented to have impacted alluvial aquifers, and thus may subsequently impact underlying bedrock aquifers that source private wells. Proposed ground water sampling will provide data on water quality that presently is consumed for these purposes. Available information on ground water flow suggests an original generally northward direction of ground water flow in bedrock aquifers, in which most existing private wells are expected to be completed, In the Ambrosia Lake sub-district, well records that are available from the New Mexico Office of the State Engineer indicate that most wells are located south of two legacy uranium mill sites as well as the mine sites from which dewatering effluents originated. Therefore legacy uranium site-related contaminants that may be detected in these wells could originate from the reported historical extensive flows from the Ambrosia Lake area effluents which may have infiltrated the bedrock aquifers through structural and stratigraphic interconnections to the Alluvial aquifers.	NMED is aware that mining companies currently are sampling some wells in support of mining permit submittals. NMED will examine these data prior to instituting its own sampling program to determine whether the quality will meet this objective. The lack of documented wells north of the Ambrosia Lake area legacy uranium sites may render detection of ground water contamination difficult. Preliminary NMED reconnaissance of wells in this area suggests that documentation for existing private well completions (i.e., aquifer identification, well depth) is poor. Therefore the identification and differentiation of impacted aquifers may only be inferred from hydrochemical and isotopic patterns, and owner knowledge, as available. Sampling of wells on the Navajo Nation should also be considered in conjunction with ongoing and proposed EPA Region 9 activities.	
	2009		4. Sample and analyze private wells for contaminant metal and wet chemistry concentrations, and for isotopic composition of contaminants related to uranium extractive activities			

Potential contaminant release pathway	Proposed activity timeframe	Activity		Rationale	Comments	Required resources additional to NMED
Ground water, soil	TBD	Assess contaminant releases to Alluvial sediments and ground water via leaching from “dry” uranium mine site waste materials and ore stockpiles.	<ol style="list-style-type: none">1. Compile and review historical data on abandoned uranium mine sites within the Poison Canyon area in order to identify 1 or more mine sites in close proximity where a) on-site heap leaching did not occur; b) mine waste and/or ore stockpiles remain exposed on the land surface; and c) drainage channels that either originate from the site or that are isolated from topographically higher uranium mine sites on which heap-leaching did occur can be identified.2. Secure access to the site(s) and contiguous properties as necessary.3. Conduct resistivity surveys to determine areas of alluvial saturation within transects across the mine site(s).4. Install monitoring points to collect Alluvial ground water samples for analyses of metals, wet chemistry, concentrations, and radionuclide activity.5. Collect stream bed sediment samples in transects within drainages in the vicinity of the mine site(s).6. Identify and address data gaps.	Mines within the Poison Canyon area primarily accessed ore bodies above the water table (“dry” mines); this contrasts to deeper mines of the northern Ambrosia Lake sub-district where extensive and continuous mine dewatering was necessary to access ore bodies. Thus, for those mine sites in the Poison Canyon area where on-site heap leaching was not conducted, the primary potential contaminant pathway to Alluvial ground water and sediments is expected to be rainfall leaching of contaminants from waste and ore stockpiles that remain on abandoned mine sites.		<ul style="list-style-type: none">• Access• Resistivity surveys• Drilling• Well installation

Potential contaminant release pathway	Proposed activity timeframe	Activity		Rationale	Comments	Required resources additional to NMED
Ground water, soil	TBD	Assess potential impacts from legacy uranium sites to Alluvial and streambed sediments from mine water discharges.	<ol style="list-style-type: none">1. Compile and review historical data on abandoned uranium mines sites that are not being addressed by NMED's abatement regulations or MMD's AML program.2. Secure access to sites(s) and contiguous properties as necessary.3. Conduct resistivity surveys to determine areas of alluvial saturation within transects across the mine sites.4. Install monitoring points to collect alluvial ground water samples for analyses of metals, wet chemistry concentrations, and radionuclide activity5. Collect stream bed sediment samples in transects within drainages in the vicinity of mine sites and throughout the entire drainage where mine water was discharged to the surface (i.e., Rio del Puerto drainage from Ambrosia Lake to the intersection of highways 506 and 605 and the San Mateo drainage from San Mateo to Milan).6. Identify and address data gaps.7. Conduct similar investigations of mines in the Laguna and Marquez sub-districts	Mines throughout the Ambrosia Lake sub-district relied on dewatering to reach the ore bodies for ore removal. From the late 1950s to the mid-1970s, untreated mine water, which contained elevated concentrations of radium selenium sulfate, TDS, and uranium was discharged to the surface. These discharges recharged or created alluvial aquifer saturation and may have impacted bedrock aquifers below the alluvial aquifers via natural and manmade interconnections.		<ul style="list-style-type: none">• Access• Geophysical surveys• Drilling• Well installation

13.0 Figures

DRAFT

Figure 1: Grants Mineral Belt

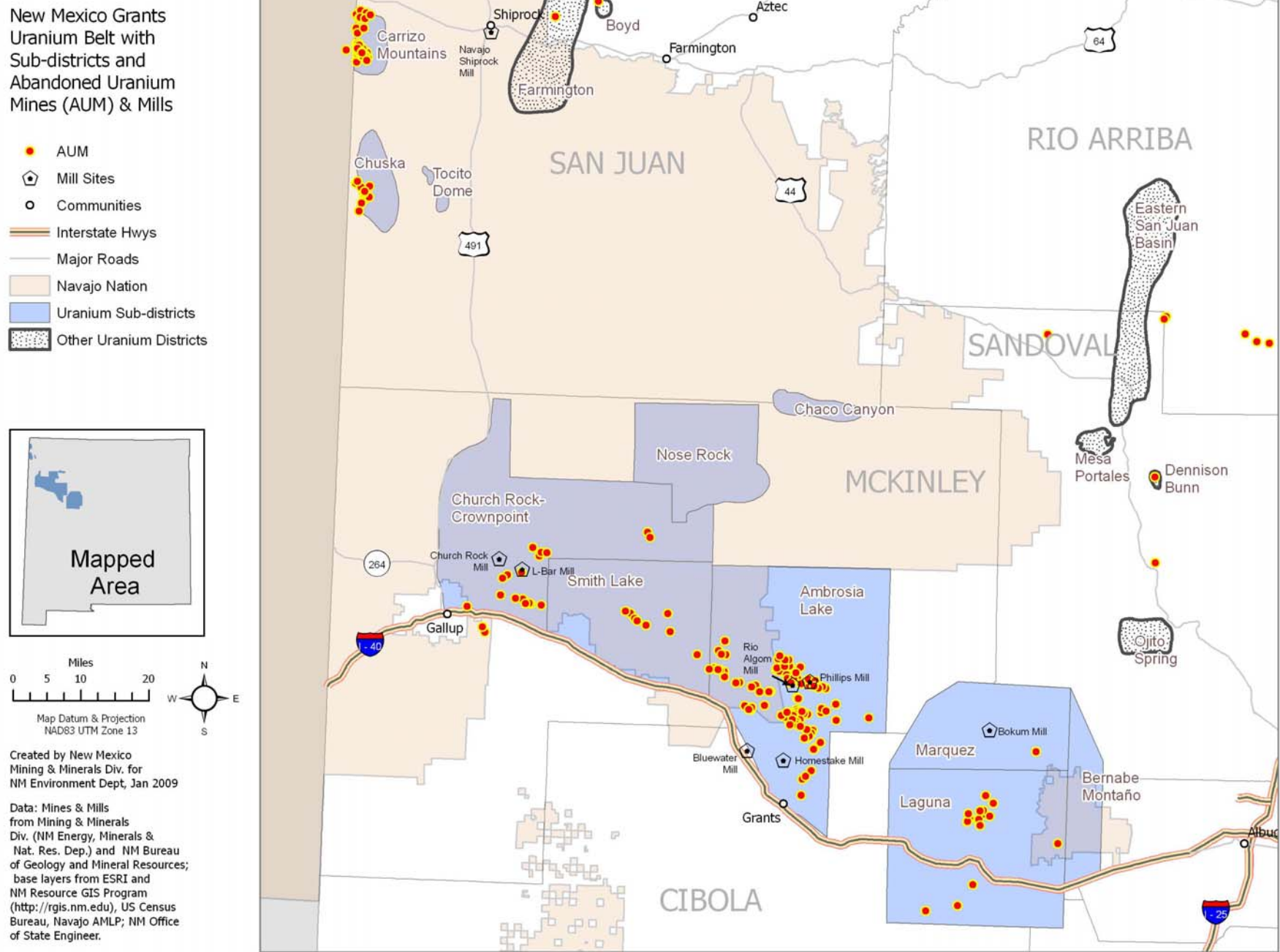


Figure 2: Ambrosia Lake legacy uranium sites shown by operator, showing surface ownership

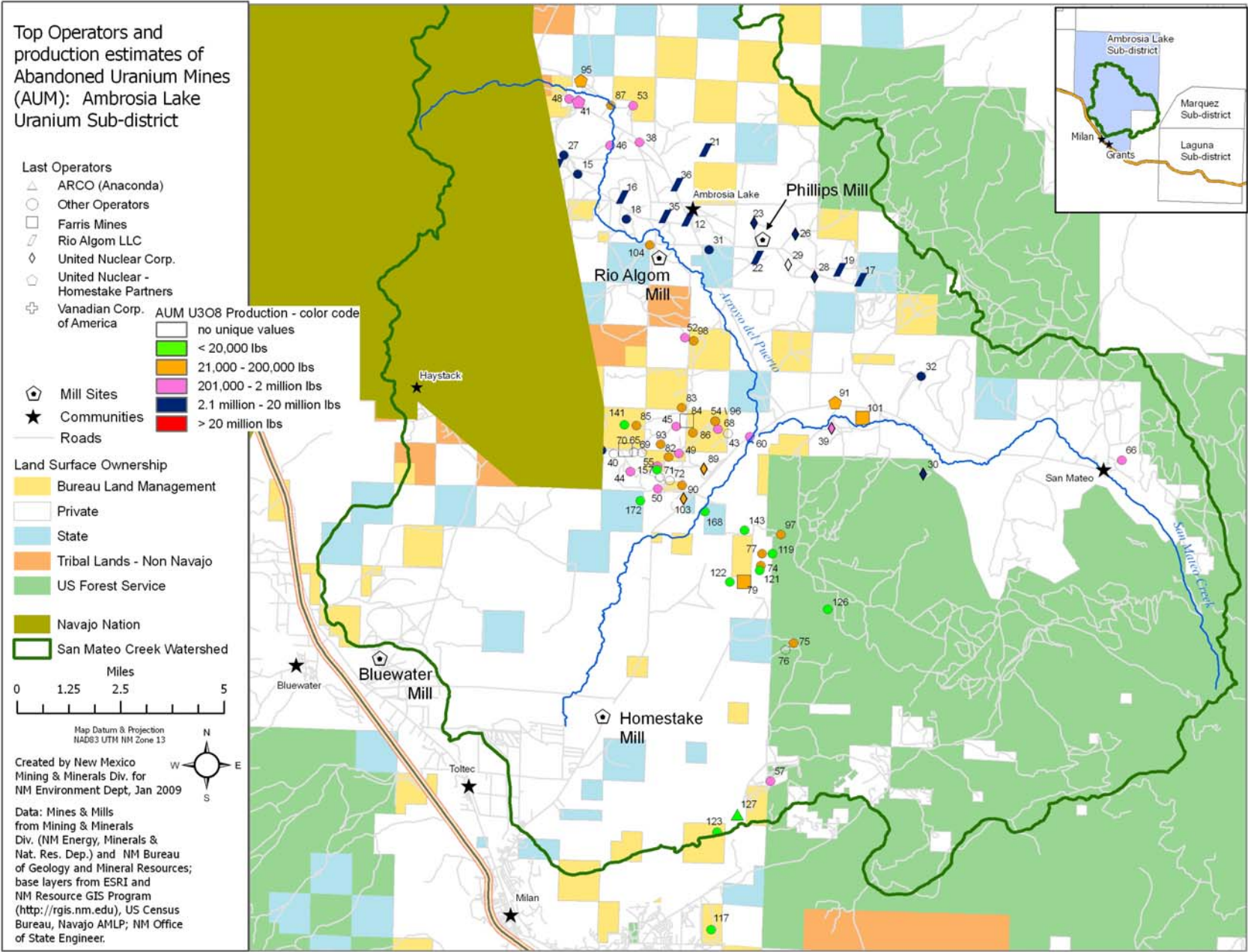


Figure 3: Ambrosia Lake sub-district legacy uranium sites by production category, showing surface ownership

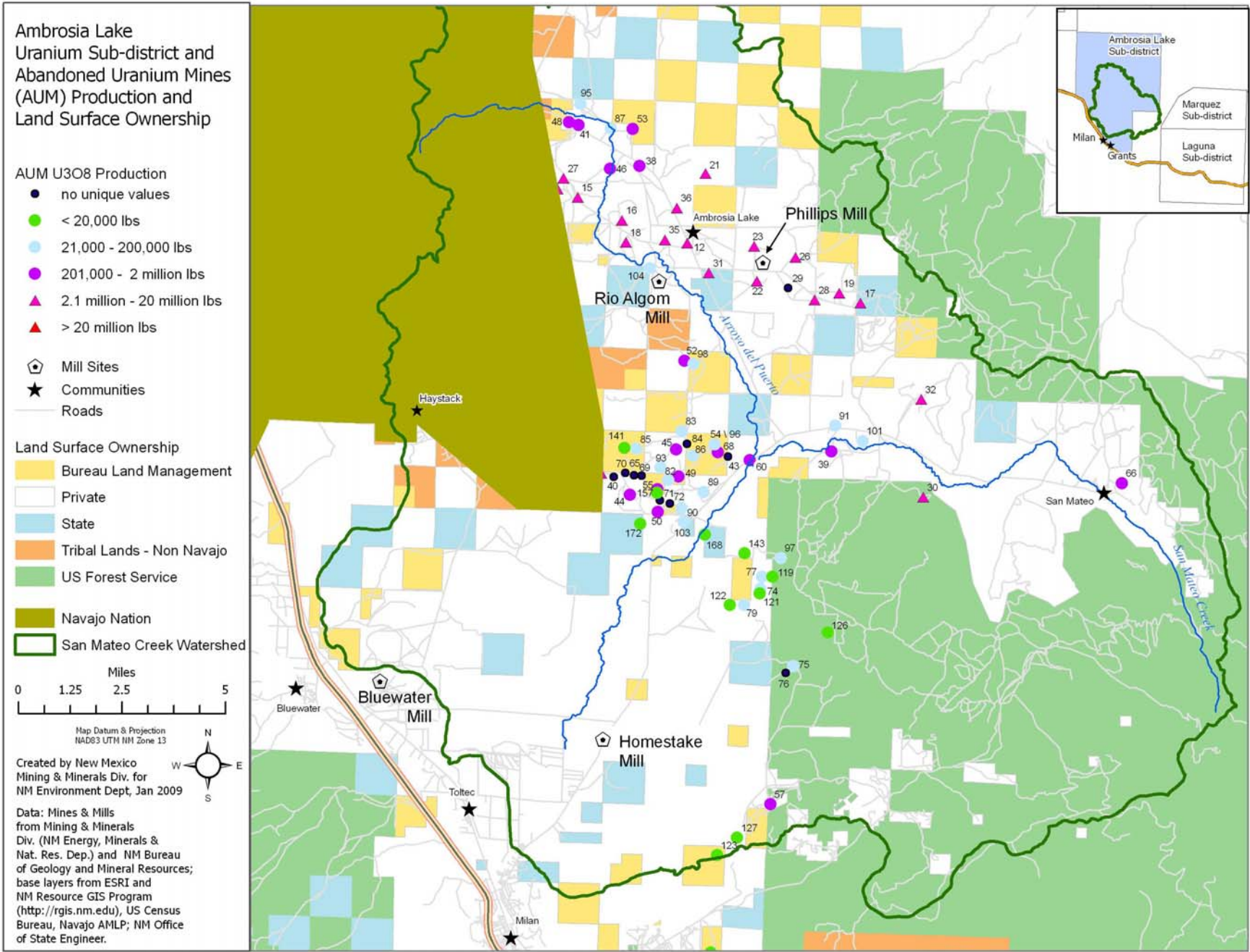


Figure 4: Ambrosia Lake sub-district legacy uranium sites by production method, showing OSE wells and municipal water systems

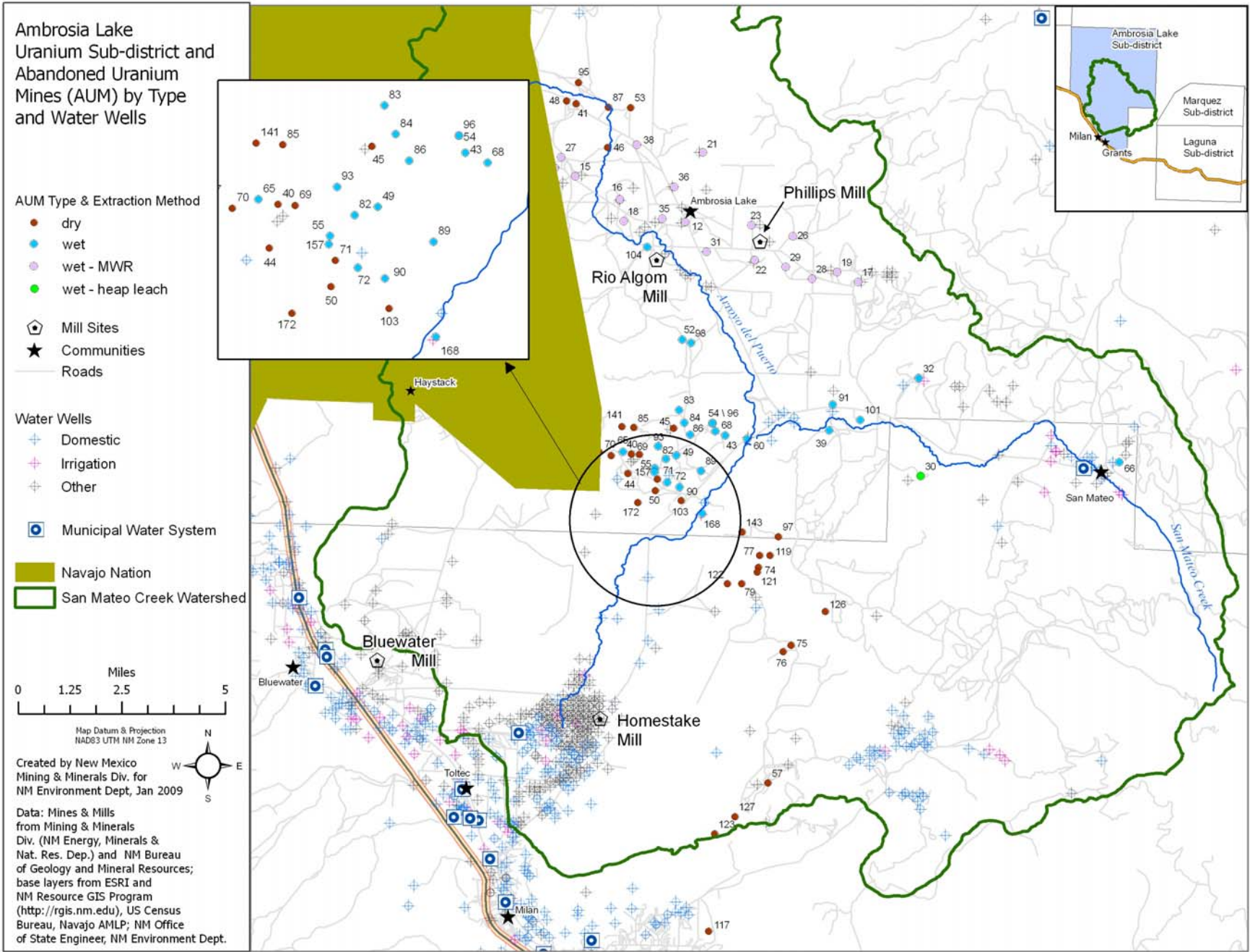


Figure 5: Laguna and Marquez sub-district legacy uranium sites, by operator showing surface ownership

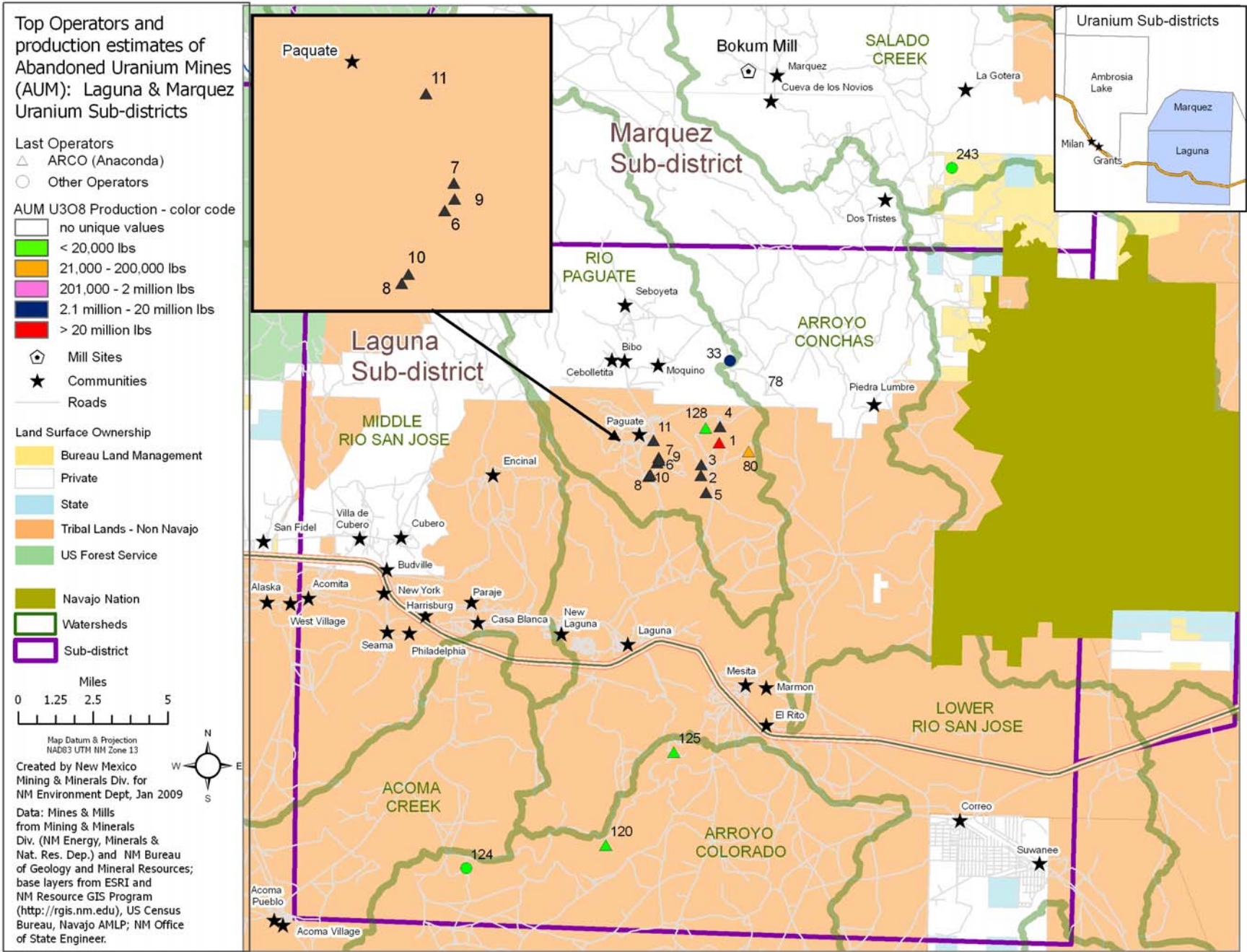


Figure 6: Laguna and Marquez sub-district legacy uranium sites by production category, showing surface ownership

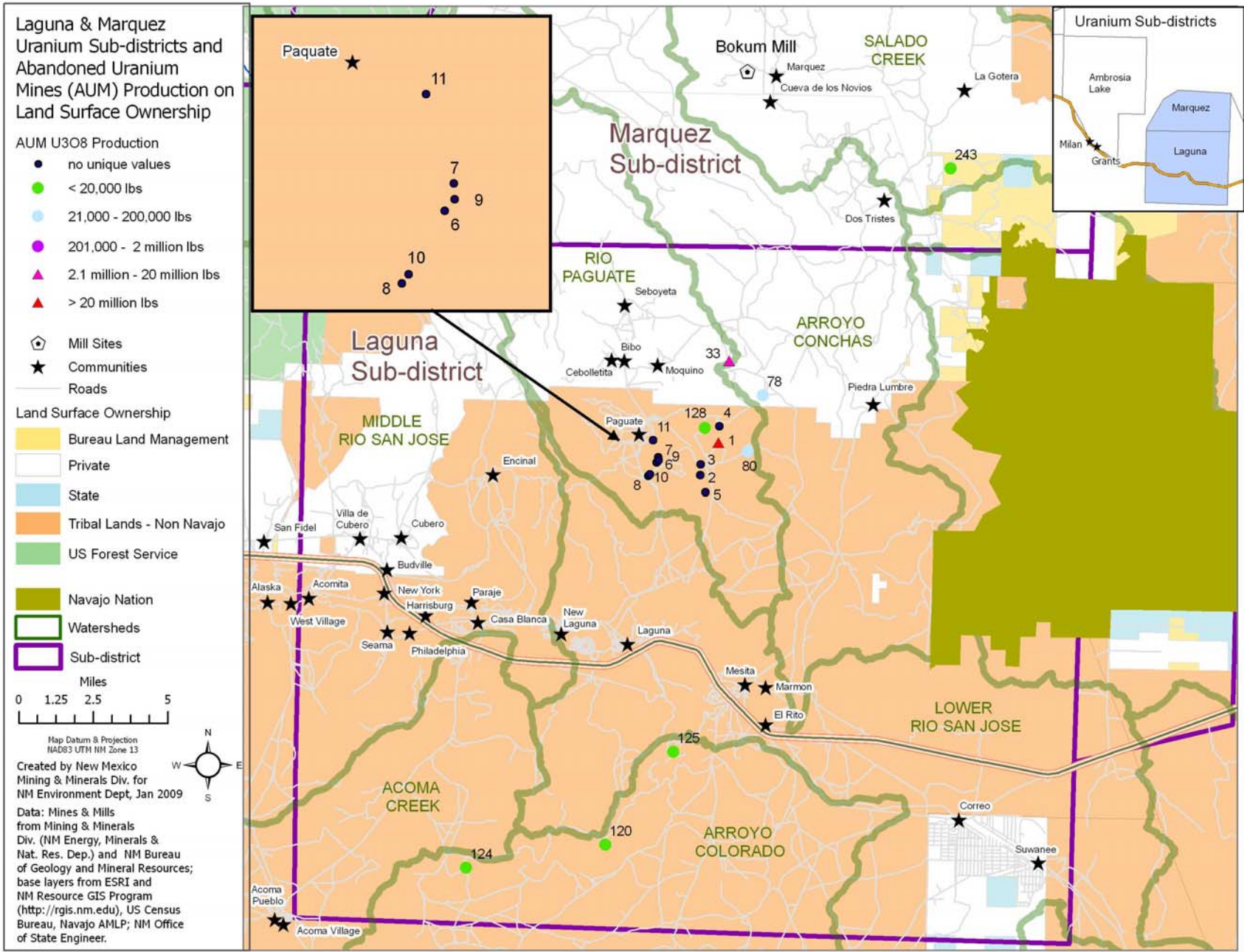


Figure 7: Laguna and Marquez sub-district legacy uranium sites by production method, showing OSE wells and municipal water systems

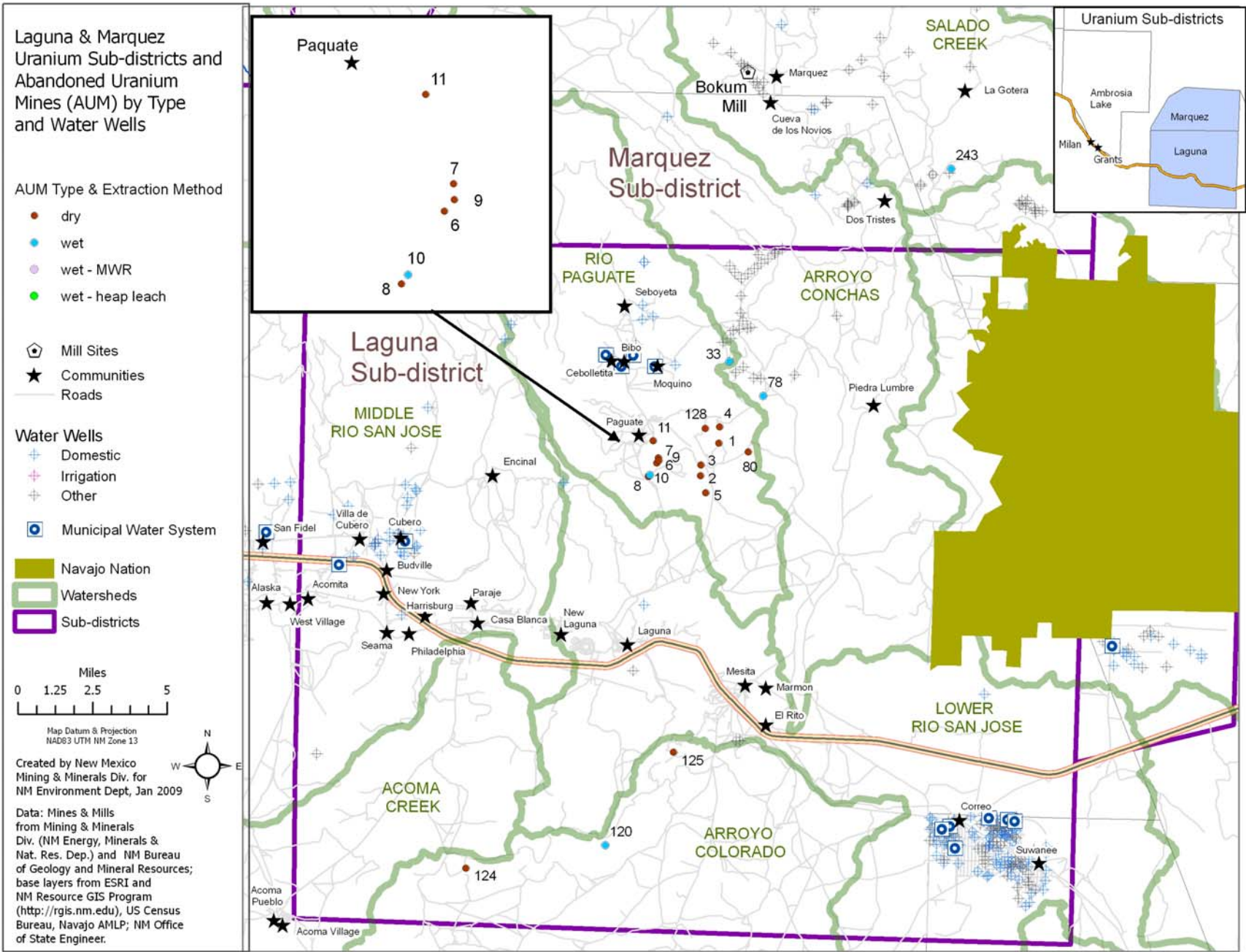


Figure 8: Ambrosia Lake proposed assessment activities

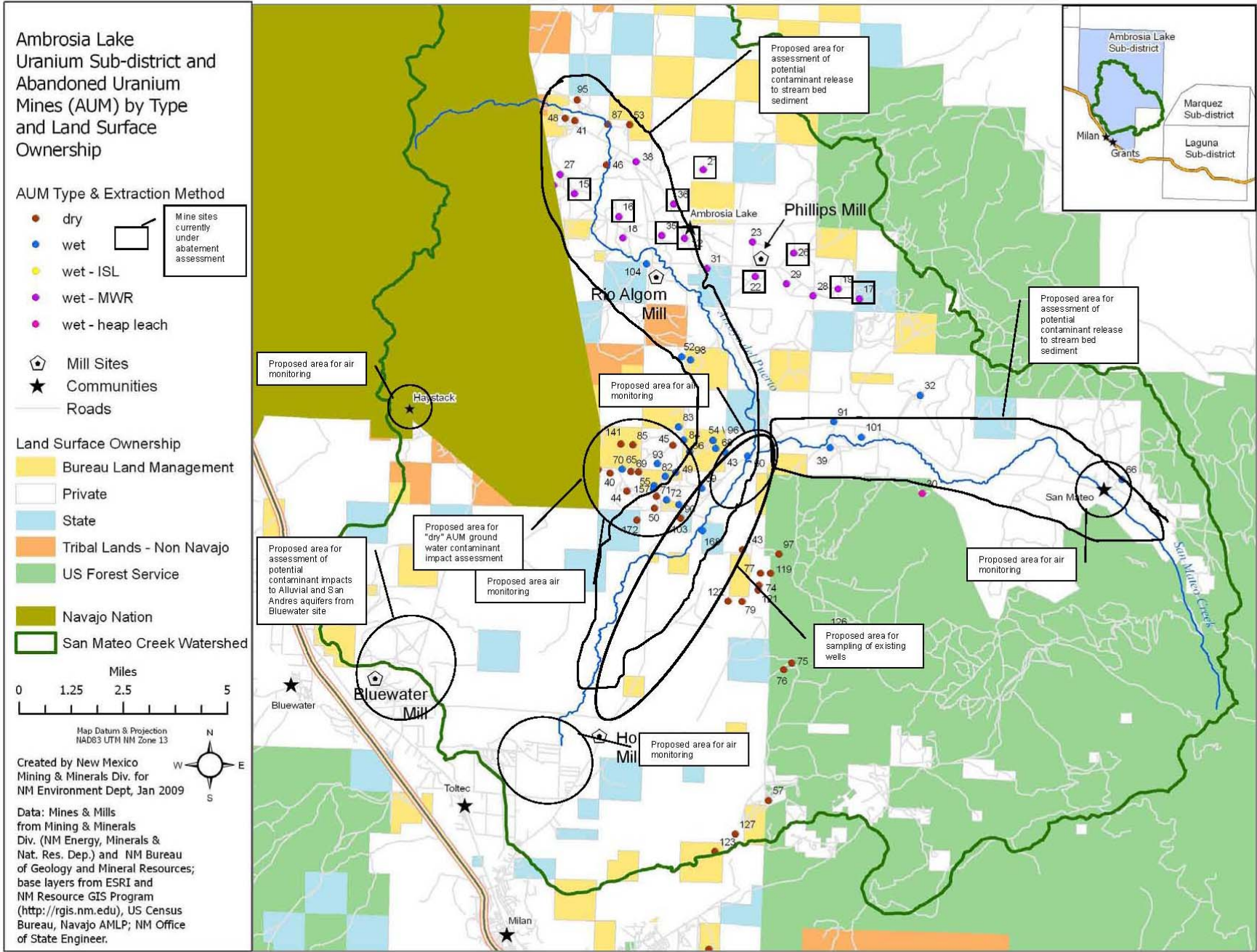


Figure 9: Laguna and Marquez sub-district proposed assessment activities

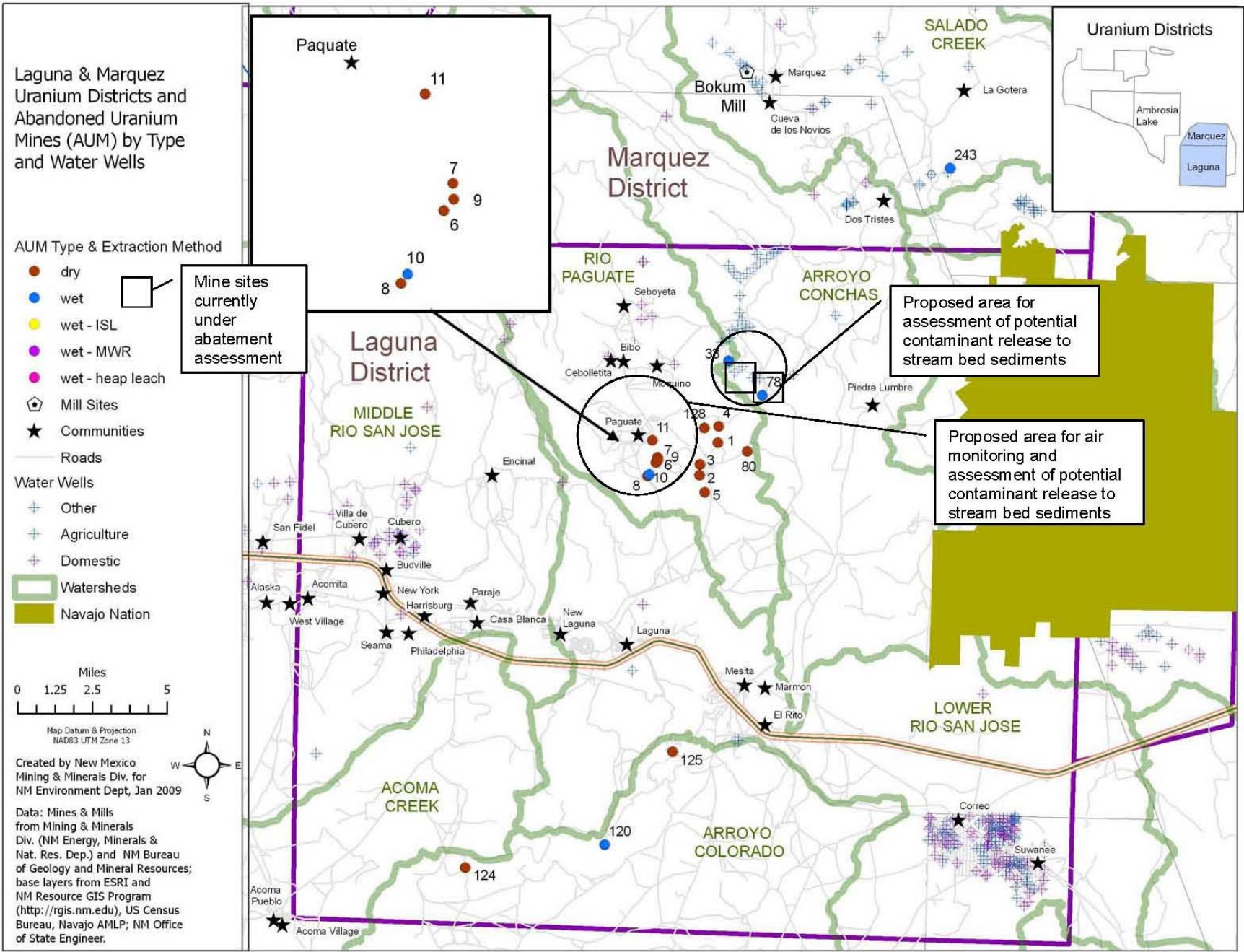
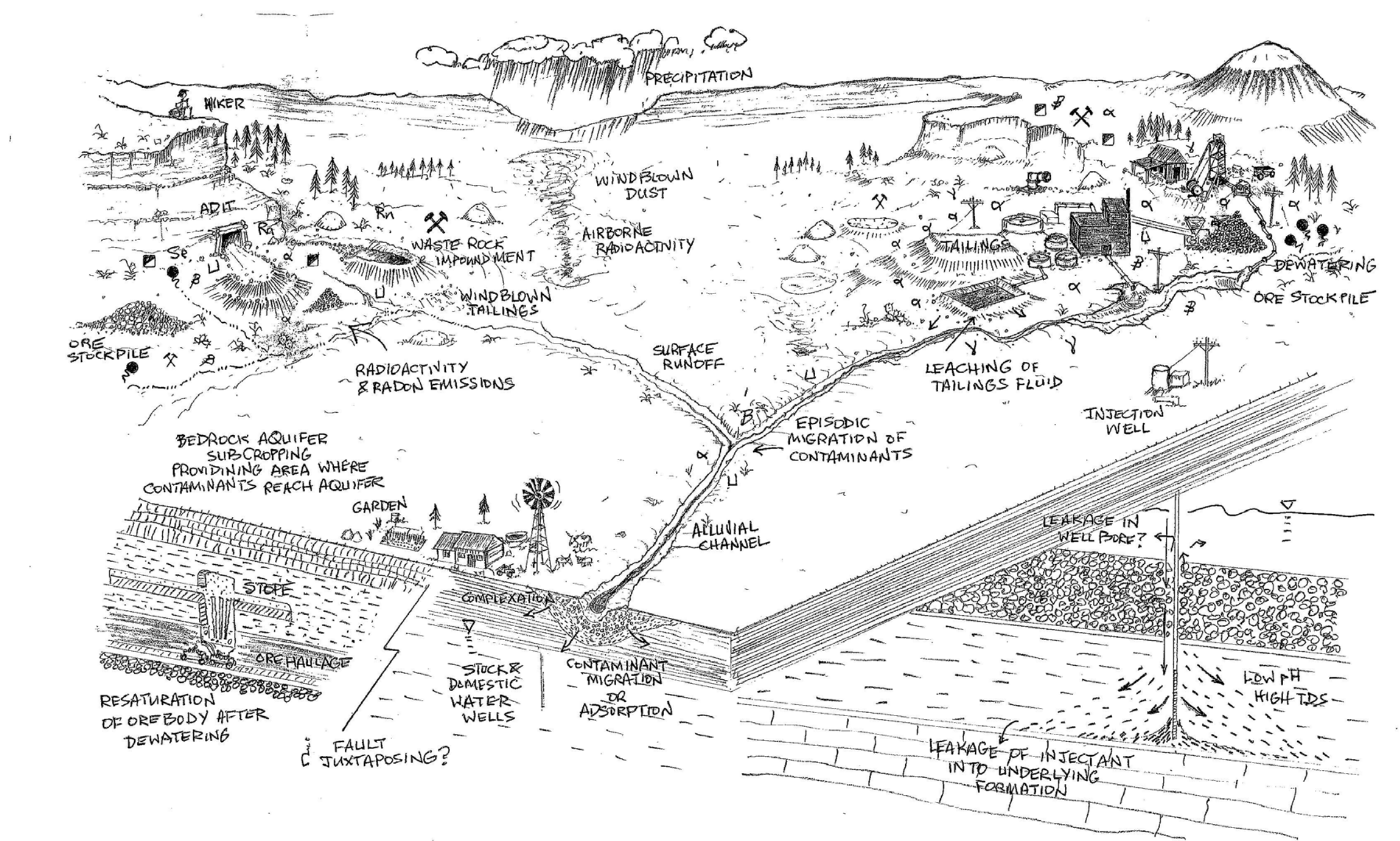


Figure 10: Conceptual model of contaminant migration within the GMB



Drawing by Earle Dixon